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ABSTRACT

A short term longitudinal study investigated the relationship between spatial activity and spatial competencies over the course of the preschool years. A group of 22 children, 3 years of age, were observed exploring two different novel environments with their mothers: an indoor children's museum and a small outdoor zoo. When the children were 3.5 to 4 years of age, they were given three tasks assessing ability to manipulate spatial knowledge of their preschool playground. Tasks assessed children's ability to use both near and distant landmarks, to infer spatial information not directly experienced, and to construct a toy model of the playground. Subjects were also given the Peabody Picture Vocabulary Test. One year later, 20 of the original 22 again received the assessment tasks, and teachers rated their attitudes toward exploring environments and materials. On the basis of initial observations, these preschool aged children were later classified as active or passive explorers. Overall, results indicated that: (1) passive and active explorers perform equally well on tasks assessing spatial competencies mastered earlier; (2) on tasks of moderate difficulty, passive explorers perform more poorly than active explorers but catch up later; and (3) on very difficult tasks, differences between active and passive explorers may be slight or nonexistent but may develop later. (RH)

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Children's Exploration of Large-Scale Environments: Effects on the Early Development of Spatial Concepts

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Anyone who has done research on the spatial competencies of young children has known of a few children who perform complex spatial tasks nearly as well as adults - and probably of a few adults who perform more like young children! For example, in discussing his research on children's ability to create maps of their neighborhoods, Hart (1981) noted considerable individual differences between children within the same age range. He cited the example of Davy, a 6-year-old boy who constructed a far more accurate, well integrated map than most of the 10- to 12-year-olds in his study. What factors might lie behind such individual differences in spatial competency?

Very little is known about this question, since research inspired by Piaget's work has focused on universal structural developments rather than variations influenced by experiential factors. However, given that development results from ongoing transactions between organism and environment, it is important to investigate the types of actual transactions children have with the environments they inhabit, and the effect these transactions have on their developing spatial competencies. Such investigations are of particular interest to educators, who can use such information to optimize children's early acquisition of spatial concepts.

One factor that might influence the early development of spatial competencies is the extent to which the child's exploration is active and independent. There are both theoretical and empirical reasons to believe this might be the case. Piaget has emphasized the importance of active interaction with the environment, especially during the early years. Also, Held and his associates have demonstrated the importance of self-produced movement for the

development of visually guided spatial behavior in animals (Held, 1965). More recently, Feldman and Acredolo (1979) found that children who walked by themselves to a location remembered the location better than children who were led to the location by an adult.

In naturalistic situations, children are able to choose how actively and thoroughly they want to explore an environment. Are there consistent individual differences in the extent to which children explore actively versus passively? And if so, do children who consistently explore more actively have an advantage in the development of spatial concepts?

I examined these questions in a study I did a few years ago (Hazen, 1982). Children from 1½ to 3½ years of age explored in a children's museum with their mothers. I observed both the amount of their exploration (the number of different exhibits they visited) and the mode of their exploration (active versus passive). Exploration was defined as active when the child made the decision of where to explore, either by moving independently or by leading or verbally directing the mother. Exploration was defined as passive when the mother made the decision, either by physically leading or carrying the child, or by giving verbal directions.

To see if amount and mode of exploration were consistent across situations, these same children were observed exploring in a completely different environment, a laboratory room containing a playhouse. Later, children were tested on their knowledge of the spatial layout of the laboratory playhouse. They were taught a specific route through the playhouse to reach a goal, and were then required to make detours in order to reach the goal and to reach the goal from other starting points. Children who were more independent in their exploration displayed more accurate knowledge of the laboratory playhouse by inferring more direct routes to the goal. Also, independence of exploration was consistent across situations.

Children who explored more independently in the museum also explored more independently in the playhouse. However, there was no correlation between amount of exploration in the two settings, nor was amount of exploration related to spatial competency.

The results of this study thus indicated that very young children's developing spatial concepts are effected not so much by how much ground they cover during exploration, but by the extent to which they independently direct their own exploration. Also, there appear to be stable individual differences in the extent to which young children's exploration is self-directed (active) versus other-directed (passive).

If self- versus other-directed exploration is consistent within individual children across situations, it may be that individual differences in modes of exploration correspond to individual differences in spatial information processing. But how might active versus passive explorers differ their abilities to encode and manipulate spatial information?

Feldman and Acredolo (1979) suggested that preschoolers who explore actively are able to encode topographic information more effectively than preschoolers who explore passively. Their hypothesis is based on Piaget and Inhelder's (1967) contention that preoperational children's spatial representations are largely topographical, that is, encoded primarily in terms of proximity between landmarks. Older children are better able to use information about distance and angles in order to encode spatial information and thus need not encode as much information about direct relationships between landmarks in order to remember spatial locations. In support of their hypothesis, Feldman and Acredolo noted that although preschoolers who were led to a location did not remember the location as well as children who moved independently, 9- and 10-

year-olds remembered locations equally well in both conditions.

Passive explorers might also have more difficulty than active explorers when integrating separately acquired bits of spatial information. That is, if they know the spatial relationship between A and B, and between B and C, they may have difficulty putting this information together in order to infer the relationship between A and C. This ability to make spatial inferences is critical if one leaves a known route, as when one wishes to take a detour or shortcut. In my study (Hazen, 1982) passive explorers did have more difficulty than active explorers when required to take a detour from a known route. However, it was not clear whether their problem stemmed from a failure to integrate separately encoded "views" of topographic information, or a failure to encode relevant topographic information in the first place.

Finally, if these individual differences in young preschool children's spatial exploration result in differences in their ability to encode and integrate topographic information, what will be the developmental course of these differences? Over the course of development, as children become more competent in encoding and integrating topographic information in large-scale environments, perhaps differences in the spatial competencies of active versus passive explorers will diminish and eventually disappear. One might expect that as children's encoding and manipulation of spatial relationships shifts from being primarily sensori-motor and behavioral to primarily symbolic and representational, active exploration will become less important for spatial cognitive development. On the other hand, if there is developmental continuity between acting on space and symbolically representing space, passive explorers may later be delayed relative to active explorers in the acquisition of higher order, symbolic spatial competencies.

To investigate the relationship between spatial activity and spatial competencies over the course of the preschool years, I conducted a short-term longitudinal study. A group of 22 3-year-old children were observed exploring two different novel environments with their mothers - an indoor children's museum and a small outdoor zoo. Six months later, when the children were 3½ to 4 years of age, they were given three tasks to assess different levels of their ability to manipulate their spatial knowledge of a very familiar environment - their preschool playground.

The first task (animal location task) was designed to assess the children's ability to use both near and distant landmarks (topographical information) to encode spatial locations. The experimenter and child walked from a "home base" to a particular location on the playground. The experimenter then placed a toy animal on that location and told the child that the animal wanted to live at that place. The experimenter then returned to the home base with the child and the animal, and asked the child to return the animal to the place where it wanted to live. This procedure was repeated for five other locations using 5 different toy animals. For the first 3 locations, the animal was placed in direct proximity (within 2 feet) to a distinctive landmark. For the last 3 locations, the animal was placed at least 6 feet from the nearest landmark. Thus, for the first three placements, the child would need to use only topographic information to correctly replace the animal, but for the last 3 placements, some distance and direction information would be needed as well.

The second task (pointer task) was designed to assess the children's ability to infer spatial information that they had not directly experienced. The child and the experimenter stood inside a room which led out to the playground. In front of them was a pointer mounted on a circle which was marked with degrees. The child could not see any of the play equipment from inside the room. After

making sure that the child could recognize photographs of all the playground equipment, the experimenter showed the child a photograph of each particular piece of play equipment and asked the child to point directly to that item with the pointer. The experimenter then recorded the angle of the pointer for each item.

For the third task (model reconstruction), children were required to reconstruct a model of their playground using toy pieces. This was presumed to be a higher-order task requiring a greater degree of symbolic spatial representation. The first and second tasks involved mental manipulations which were performed on the actual space, i.e., replacing objects within the space itself or pointing to landmarks within the space itself. The third task, in contrast, involved performing mental manipulations on a symbolic representation of that space. This task required the children to transform their knowledge of the layout of the familiar playground to a reduced scale, using toy objects which symbolized the actual objects. Before beginning, the experimenter made sure the children could identify the piece of playground equipment that each toy was supposed to represent by matching it to a photograph of the item it represented. The toy pieces were very realistic, detailed models, so children had no trouble with this. The experimenter spent a considerable amount of time explaining the model and its correspondance to the real playground to the children. She then placed two toy pieces on the model, explaining that she was placing them "exactly where they go on the real playground." Then the child was told to replace the other toy pieces "where they really go."

Thus, each of these three tasks required different types of spatial manipulations to be performed on the same environment. I purposely selected an environment that would be very well known to the children so that knowledge of the environment itself was not likely to be confounded with the particular

spatial manipulation of interest. That is, if a child did not point correctly to the sandbox, it was more likely to be because he could not infer its location from inside the door, rather than because he forgot about the sandbox itself. Clearly, all of the children could easily find their way from one piece of equipment to another when actually on the playground. I also gave the children a recognition task in which they were shown pictures of items which were on their playground and items which were not on their playground. All of the children were able to discriminate between these two sets of pictures with nearly 100% accuracy.

During this same year, the children were also given the Peabody Picture Vocabulary Test, a test of verbal intelligence. One year later, when they were between 4½ and 5½ years old, 20 of the original 22 children again received the animal location task, the pointer task, and the model reconstruction task. Finally, their preschool teachers rated them on their attitudes toward exploring environments and materials.

Children were later classified as active explorers or passive explorers based on the observations of their exploration that were collected when they were 3 years old. Two Activity Scores (indoor and outdoor) were derived for each child by dividing the number of active movements by the number of active plus passive movements made in each setting. The Activity Scores for indoor and outdoor exploration were highly correlated, $r(20)=.66$, $p<.01$, therefore the two Activity Scores were averaged. Children whose average Activity Score was above the median were classified as active explorers; the rest were classified as passive explorers. These Activity Scores were positively correlated with the teacher ratings obtained two years later of independence of exploration, $r(18)=.37$, $p<.05$, and negatively correlated with ratings of dependence on adults, $r(18)=-.44$, $p<.05$. Thus, individual differences in mode

of exploration were found to be quite stable throughout the preschool years.

But how did the active and passive explorers differ in their abilities to manipulate spatial information over this two year period? Figure 1 graphically depicts the scores of the active and passive explorers in the animal location task for the three locations which were directly marked by landmarks. Scores were calculated by summing for each of the three placements the number of feet the animal was placed from the actual location. Thus, the lower the score, the more accurate the performance. Clearly, children in both groups performed extremely well in this task and did not differ significantly, although there was a slight improvement overall from the first year to the second.

But a different picture emerges when we look at the animal location task scores for the three locations which were indirectly marked by landmarks (see Figure 2). This task was clearly more difficult for both active and passive explorers than the preceding task, but in addition, the passive explorers had more difficulty than the active explorers the first year they completed this task, $F(2,18) = 3.73$, $p = .07$. The second year, the gap between the active and passive explorers narrowed to an insignificant difference, $F(2,16) = .594$, N.S.

Thus, it appears that using topographic information to encode locations was easy for all preschool-aged children when landmarks directly marked locations, but was more challenging when landmarks indirectly marked locations. This is consistent with recent evidence that even 9-month-old infants can use topographic information to encode directly marked locations in familiar environments (Acredolo, 1979). Passive explorers had more difficulty than active explorers encoding information about the distance and direction of locations from indirect, more distant landmarks. However, they caught up in this ability at around 5 years of age, at least when the environment was familiar.

A similar pattern of results was found for the pointer task. This task was scored by giving the child one point for each time he or she pointed to within 10^{o} of the correct orientation. (Children pointed to 9 locations, so scores could range for 0 to 9). Again, active explorers performed significantly better than passive explorers the first year, $F(2,18) = 7.16$, $p = .02$, but by the second year, the difference between the two groups was not significant, $F(2,16) = .602$, NS. Passive explorers thus seemed to have more difficulty than active explorers in inferring spatial relationships within familiar spaces, but again, this difference diminished later in the preschool years.

The model reconstruction task was scored in two ways. Absolute scores were calculated by giving the child one point for each of 11 playground items which were placed on the correct location (within 2 inches on the model = within 6 feet on the playground). Relative scores ranged from 0-22 based on the number of relationships between individual items which were correctly represented. For example, the child would receive one point if the sandbox was placed correctly by the swings, even if both of these items were not located correctly in an absolute sense. Thus, the relative score could be considered a lower-level measure of model reconstruction performance since it measured the child's ability to transfer only topographic spatial knowledge to a reduced scale, whereas the absolute score required the child to transfer distance and directional information as well.

A different pattern of results was found for the model reconstruction task as compared to the other two tasks. The difference between the relative model scores of active and passive explorers was of borderline significance the first year, $F(2,18) = 3.83$, $p = .07$, and became considerably greater the second year, $F(2,16) = 11.51$, $p < .01$ (see Figure 4). The absolute model scores were

uniformly low for both groups the first year, $F(2,18) = 2.83$, N.S., but the second year active explorers scored significantly higher than passive explorers, $F(2,16) = 4.26$, $p = .05$. Thus, whereas the difference between active and passive explorers decreased from the first to the second year for the animal location task and the pointer task, it increased for the model reconstruction task. The differences in the spatial competencies of active and passive explorers could not be attributed to differences in general intelligence, because active and passive explorers did not differ in their scores on the Peabody Picture Vocabulary Test.

Overall, then, the results indicate that during the early preschool years, passive and active explorers perform equally well on tasks which assess spatial competencies that they have mastered earlier, such as encoding locations which are directly marked topographically. On tasks that are moderately difficult for preschoolers, such as encoding indirectly marked locations and inferring relationships they have not directly experienced within familiar spaces, passive explorers perform worse than active explorers during the early preschool years, but catch up to the active explorers at around 5 years of age. On tasks that are very difficult for preschoolers, such as symbolically reconstructing spatial relationships on a reduced scale, differences between active and passive explorers may be only slight or even nonexistant during the early preschool years, but may show up more strongly later.

It may be that active exploration in environments facilitates the development of basic spatial concepts which children first apply to the actual environments they explore, and later are able to transfer to symbolic representations of spaces. Although passive explorers eventually catch up to active explorers in their abilities to encode and manipulate information about familiar environments,

their later acquisition of these abilities may delay their development of the capacity to transfer these spatial capacities to other environments, as well as to symbolic spatial representations. Thus, even though the passive explorers in our study eventually performed as well as active explorers in remembering locations and inferring spatial relationships on their familiar playground, differences in these abilities might still be found in a larger, more complex, or less familiar environment. Studies which examine the spatial abilities of active and passive children in other actual environments and using other types of symbolic representations would be useful, as would studies which follow the developmental course of these children's spatial concepts during later years.

It is of course possible that active explorers tend to explore more independently precisely because they have inherited better spatial capacities than passive explorers. Even if this is the case, experimental studies (e.g., Feldman and Acredolo, 1979) indicate that spatial knowledge of environments is facilitated by active exploration. Therefore, any incipient differences in the spatial competencies of active and passive explorers are likely to increase as active explorers continue to explore more independently than passive explorers.

This research has clear implications for educators of young children. It indicates that encouraging young children to explore actively a variety of spatial environments may be of considerable importance to the subsequent development of their capacities to represent spatial information. Studies have indicated that exposing children to models of actual environments also helps them to discover and integrate the spatial relationships present in these environments (Hazen, Lockman, and Pick, 1978). Thus, it might also be useful to encourage children to actively explore symbolic spatial representations, for example, by providing realistic models of environments that are familiar to them.

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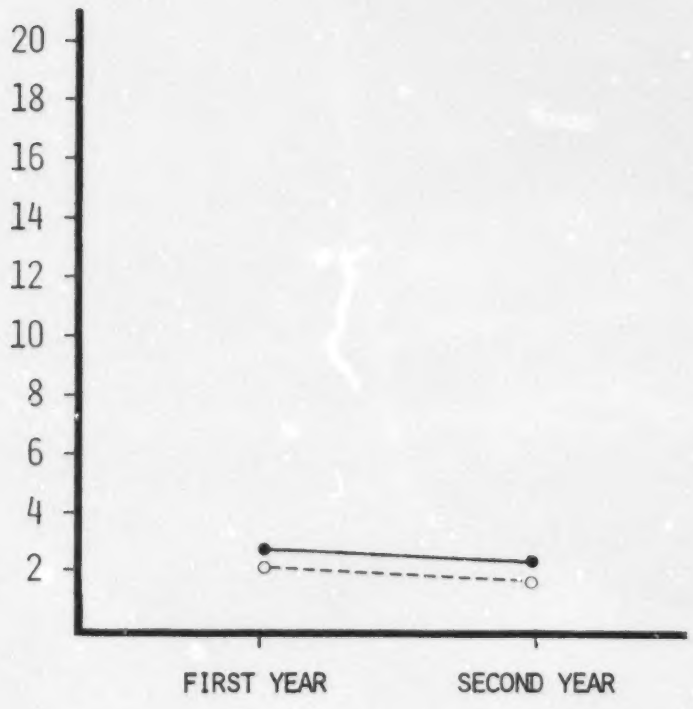
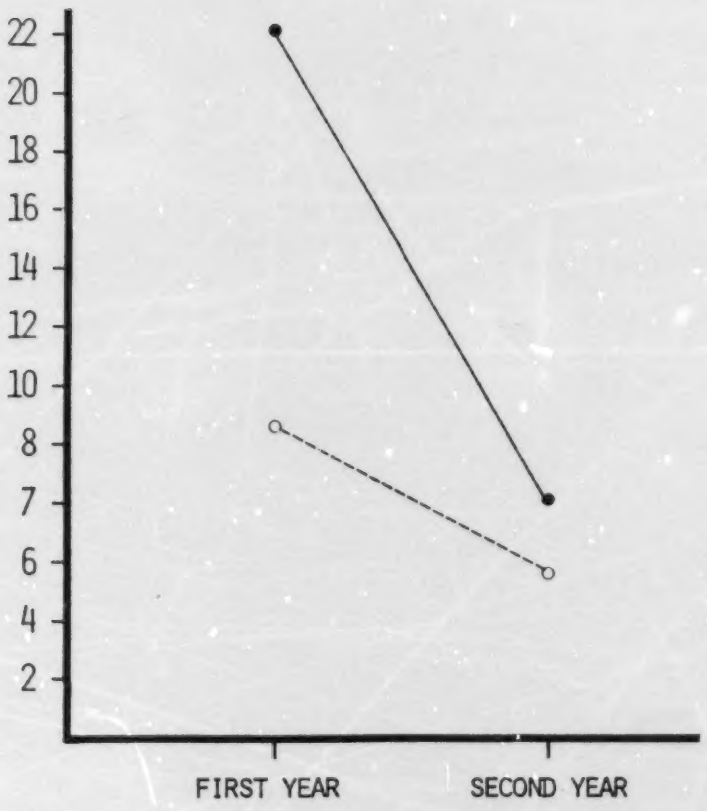
Figure 1



ANIMAL LOCATION TASK: DIRECT LANDMARKS

Figure 2



ANIMAL LOCATION TASK: INDIRECT LANDMARKS

Figure 3

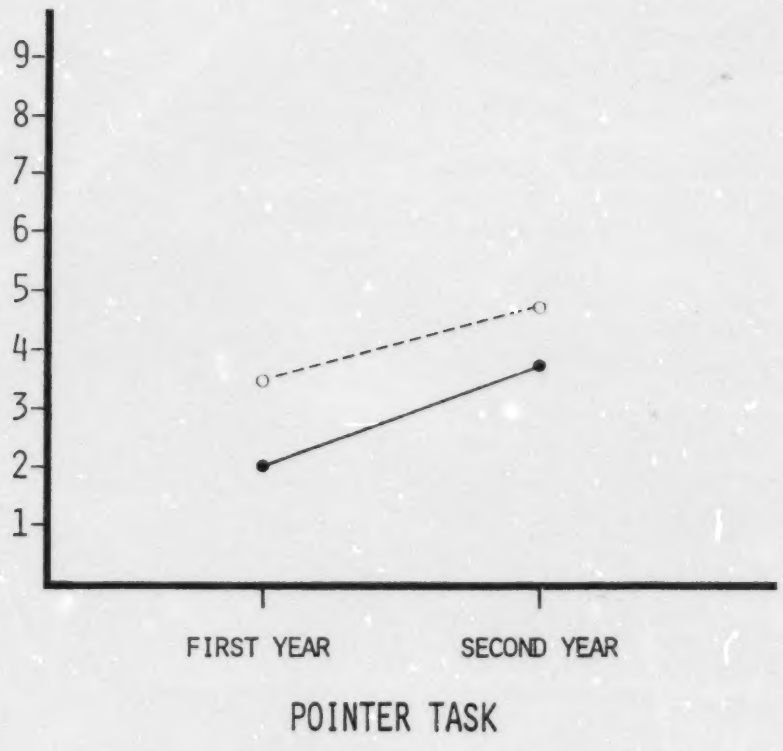
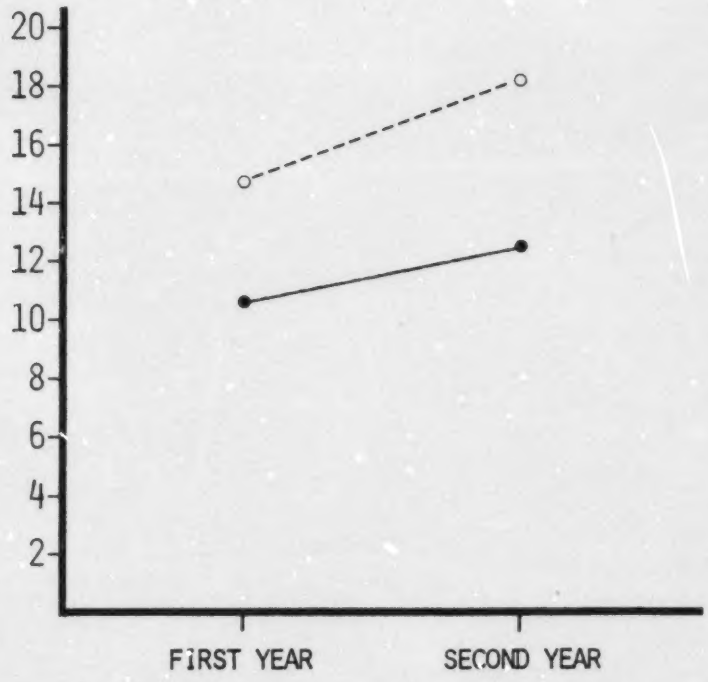
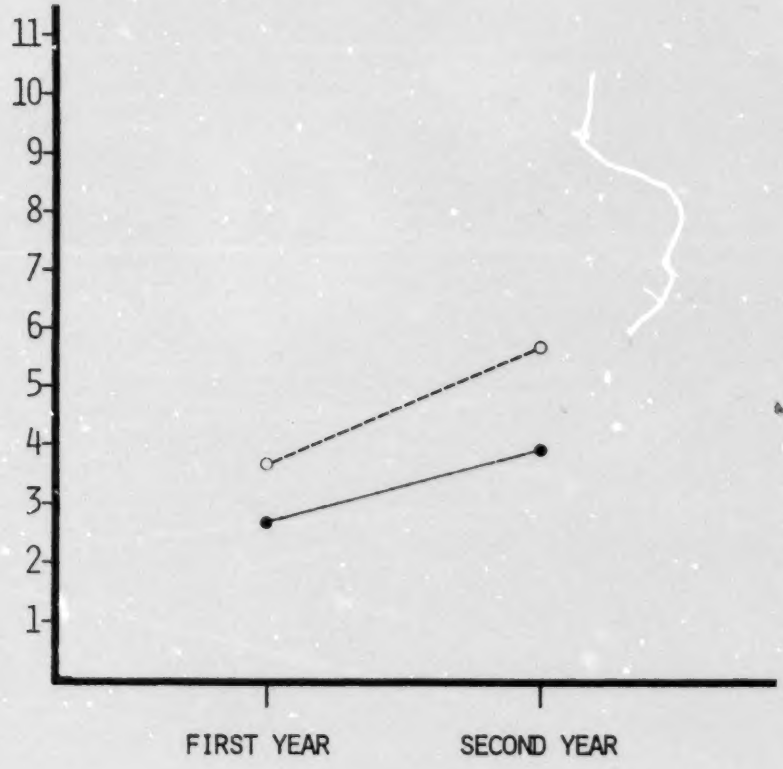


Figure 4



MODEL RECONSTRUCTION TASK: RELATIVE SCORES

Figure 5



MODEL RECONSTRUCTION TASK: ABSOLUTE SCORES